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(71) Applicant: **Hernandez Plata, Guillermo Jose**  
**Santa Fe 3435, 4 "C"**  
**1425 Buenos Aires(AR)**

Applicant: **Costa, Luis Alberto**  
**Las Heras 3898 - 1 "C"**  
**1425 Buenos Aires(AR)**

Applicant: **Coni Molina, Carlos Maria**  
**Salta 1436 - 3 "A"**  
**1137 Buenos Aires(AR)**

(72) Inventor: **Vidal, Juan Carlos**  
**5550 South Dorchester AP. 1106**  
**Chicago Illinois 60637(US)**  
Inventor: **Costa, Luis Alberto**  
**Las Heras 3898, 1 "C"**  
**AR-1425 Buenos Aires(AR)**  
Inventor: **Hernandez Plata, Guillermo Jose**  
**Santa Fe 3435, 4 "C"**  
**1425 Buenos Aires(AR)**  
Inventor: **Coni Molina, Carlos Maria**  
**Salta 1436, 3 "A"**  
**1137 Buenos Aires(AR)**

(74) Representative: **Pearce, Anthony Richmond et**  
**al**  
**MARKS & CLERK Alpha Tower Suffolk Street**  
**Queensway Birmingham B1 1TT(GB)**

(34) **Pharmaceutical composition based on crotoxine, process for preparing the active component and the pharmaceutical composition.**

(57) **Crotoxine complex sub-units A and B obtainable by chromatographic isolation from the crude venom of Crotalus Durissus Terrificus, is useful for the treatment of carcinomes and vascular, infectious or endocrinous disorders, such as diabetes, and for treating pain in general.**

**EP 0 246 861 A2**

# PHARMACEUTICAL COMPOSITION USEFUL FOR THE TREATMENT OF CARCINOMES AND OTHERS ILLNESSES AND PROCESS FOR PREPARING THE ACTIVE COMPONENT AND THE PHARMACEUTICAL COMPOSITION.

## Summary of the Invention

An object of the instant invention is a procedure for separating and purifying sub-units A and B of the crotoxin complex obtained from crude venom of Crotalus Durissus Terrificus

A further object of said invention is a method for the treatment of vascular and endocrinous illnesses, infections and carcinomas with said sub-units A and B obtained and purified according to said procedure.

A further object of said invention is to provide pharmaceutical compositions formulated on the basis of said sub-units A and B as active agent in a pharmacologically acceptable vehicle.

## Technical Field of the Invention

This invention refers to pharmaceutical compositions useful for the treatment of carcinomas, vascular, infectious and endocrinous illnesses and applicable also as analgesics, which comprise as therapeutical agent the crotoxin complex sub-units A and B obtained from the crude venom of Crotalus Durissus Terrificus in a pharmacologically acceptable vehicle. The invention also refers to a process for obtaining units A and B of said complex from said crude venom, and to a method of preparation of said pharmaceutical compositions and to methods of treatment of carcinomas and said other illnesses by administering pharmacologically efficient amounts of said compositions, and to a process for preparing the above mentioned compositions.

## Antecedents of the Invention

We have been applying the crotoxin sub-units A and B obtained with the method of this invention for four years, particularly in the treatment of cancer.

To this date results have been very good, with high percentages of objective response and overlife, as will be detailed hereinafter.

## Description of Prior Art

The analgesic effect of serpent venom has been known since antiquity and numerous authors have pointed out the efficiency of the administration of crude cobra and rattle-snake venom in the treatment of neuralgias of the trigeminal, tabetic and tumoral algias. In the case of tumoral algias, patients could be maintained without the administration of morphine and without pain in 70 per cent of the cases.

However, few authors followed up these patients. The appearance of new analgesics cast aside research in this field and the progress of chemotherapy led to the abandonment of research in the possible antineoplastic action of venoms. Obviously, at that time raw venoms were employed without an adequate classification. Sometimes, cobra venom from India or South Africa were employed indistinctly with unpredictable results.

Independently, the first cytotoxic component to be isolated and purified to homogeneity from serpent venom was citotoxin, obtained by BRAGANCA et al (1967) from Naja naja venom. Later on, TAKECHI et al (1971) isolated two cytotoxins from the same venom having high citopathogenic activity on tumoral cells. GILLO (1966), WIRTHEINER & GRILLO (1966), BRISBOIS et al (1968), proved that the Naja naja venom inhibits growth of tumors in animals (mice) as the tumoral cells are incapable of proliferating, although said cells are not destroyed.

However, the complexity in the composition of venoms and the absence of adequate control led researchers to believe that the cytotoxic action would not be selective when confronted with tumoral cells.

In contrast with cytotoxins from venom of elapids (for example, cobras), which are peptides of 59-62 strongly basic aminoacids, venom from crotalids does not contain basic peptides and its cytotoxic activity is related to other components.

The fraction identified as "crotoxine" from the venom of *Crotalus Durissus Terrificus* was isolated firstly by SLOTTA and FRAENKEL-CONRAT (1938) by thermal treatment of the venom and precipitation of alcohol. This fraction, which could be crystallized with pyridin-acetic acid to pH 4.5, and the studies on free electrophoresis (LI & FRAENKEL-CONRAT) and ultracentrifugation (GRALEN & SVEDBERG, 1938) did not illustrate gross unhomogeneities and allowed said fraction to be considered as a homogenous chemical entity.

In 1971, two research groups proved that "crotoxine" is in fact a complex formed by two main components (RUBSAMEN et al, 1971; HENDEN & FRAENKEL-CONRAT, 1971). One of said components is a Phospholipase A<sub>2</sub> having a molecular weight of 16300 and isoelectric point 9.7, also named Crotoxine B (for basic). The other of said components is a peptide having a molecular weight of 8500 and isoelectric point of 3.5, and lacking in enzymatic activity, named as Crotoxine A (for acid).

As from March 1981, we initiated a different methodology to obtain in our laboratory the two sub-units A and B of the crotoxine complex.

We have separated Phospholipase A<sub>2</sub> Basic (crotoxine B) and the acid sub-unit (Crotoxine A) as from *Crotalus Durissus Terrificus* venom with a procedure consisting in:

(1) Chromatography on Sephadex G-75 at pH 4.5, and

(2) Exchange Chromatography on Cm-Sephadex C-50 and elution with a concave gradient having an ammonia formiate molarity of 0.1 to 1.0 M (pH 3.5) followed by a linear gradient (1.0 to 3.0 M) of the same absorber. In this step the following components separate:

1) Crotoxine A;

2) A<sub>2</sub> Phospholipase having an isoelectric point of 4.1;

3) A third component identifiable as Crotamine (contaminant), and

4) Basic phospholipase A<sub>2</sub> (Crotoxine B) which is last to elide.

Crotoxine A is later purified by chromatography on DEAE-Cephadex A-50 with potassium phosphate (pH 6.5) as absorber. Phospholipase A<sub>2</sub> basic (Crotoxine B) is purified by chromatography on CM-Sephadex c-50 (pH 3.5).

The purified fractions are concentrated by ultra-filtration on membranes (Diaflo UM-10, AMICON CO., Bloomington, Ma., U.S.A) and balanced with ClNa 0.15 by extensive dialysis. The purified components behave as homogeneous materials by electrophoresis in polyacrilamide gel in the presence of sodium dodecylsulphate, high pressure chromatography as well as by aminoacids composition. In the interest of clarity, when referring to Sub-Units A and B, same correspond to : Crotoxine A (complementary peptide) and Crotoxine B (phospholipase A<sub>2</sub>) separated (isolated) or in complex form.

### Summary of the Invention

An object of this invention is a pharmaceutical composition useful for treatment of carcinomes, infectious, endocrinous and inflammatory illnesses and as analgesic, which comprises crotoxine complex sub-units A and B from crude venom of *Crotalus Durissus Terrificus* as therapeutic agent and a pharmacologically acceptable vehicle.

Another object of this invention is a process for obtaining said sub-units A and B from said crude venom, characterized in that it comprises separating by chromatography the crotoxine complex present in said venom; concentrating the fractions obtained when eluding the adsorbed crotoxine complex; dispersing in aqueous medium the non-soluble product precipitated in said concentration step; fractioning by chromatography sub-units A and B, chromatographing said dispersion in an adsorption column and eluting units A and B with a buffer solution of ammonium formiate having a pH of about 3.5, and purifying separated eluted fractions containing sub-units A and B, and eventually mixing said sub-units to form the crotoxine complex.

A further object of this invention is a method of treatment of carcinomes, infectious, vascular and endocrinous illnesses, which is also useful for analgesic treatments in general, and which comprises administering to patients therapeutically efficient amounts of a pharmaceutical composition including crotoxine complex sub-units A and B in a pharmacologically acceptable vehicle.

Still another object of this invention is a process for preparing said pharmaceutical compositions.

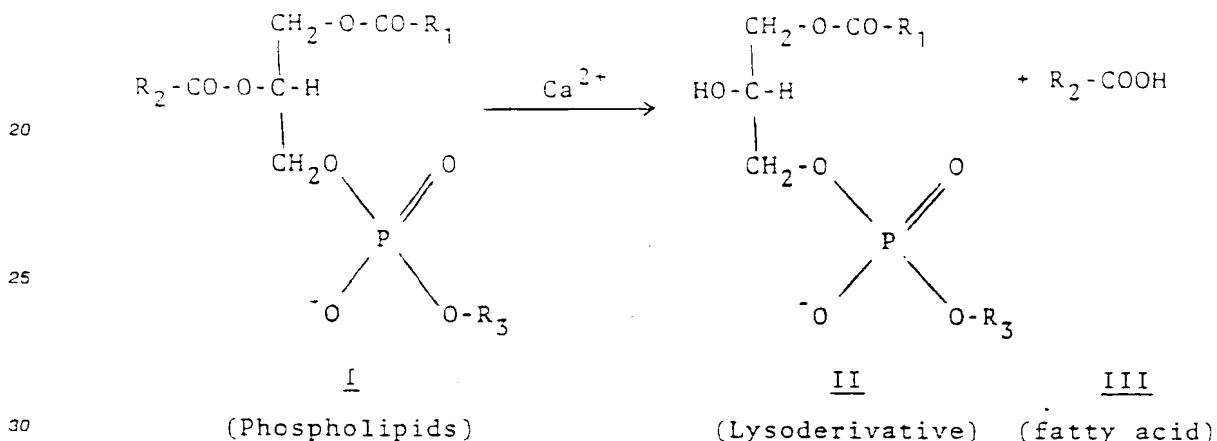
These and other objects, advantages and novel aspects of the present invention will be made evident through the below detailed description of the invention.

Detailed Description of the Invention

The present invention is based on the discovery by the applicants of certain enzymatic properties of Sub-Units A and B of Crotoxine (Crotoxine A and Crotoxine B, respectively), pharmacodynamics (action mechanism) and pharmacokinetics.

1.-ENZIMATIC PROPERTIESA) Enzymatic Properties of Crotoxine B

Crotoxine B is a phospholipase A<sub>2</sub> and catalyses the hydrolysis of the ester union between the fatty acid and the alcohol hydroxyl of position 2 of the glycerol of 1,2-diacyl (1-alkenyl-2-acyl or 1-alkyl-2-acyl)-sn-glycero-3-phosphoglycerids (pospholipids), in accordance with the following pattern:



wherein R<sub>1</sub> and R<sub>2</sub> are fatty acid residues and R<sub>3</sub> can be:

H (phosphatidic acid), a polyalcohol (glycerol in phosphatidylglycerol, inositol in phosphatidylinositol) or a nitrogenated alcohol (coline in phosphatidylcoline, ethanolamine in phosphatidylethanolamine, serine in phosphatidylserine). The reaction products are a free fatty acid (III) and the 1-acyl derivative (II) generally defined as lysoderivative (lysophosphatidylcoline, lysophosphatidylethanolamine). The hydrolysis reaction is stereospecific, exhibiting position specificity by the ester union of C-2 of glycerol and requires specifically Ca<sup>2+</sup> ions as co-factor.

The basic phospholipase A<sub>2</sub> (Crotoxine B) hydrolyzes phospholipids in different aggregation stages, such as short chain lecithines obtained by chemical synthesis, and very soluble in water, added as mycelles as well as phospholipids with long-chain fatty acids (C<sub>15</sub>-C<sub>22</sub>) added as vesicles or as liposomes, or in biologically important structures such as lipoproteins and biological membranes. Its specific activity on egg yolk lipoproteins (pH 8.0, 40°C) is of 700 ml of hydrolyzed substrate/min/mg of protein.

An important functional property in common with other lipolytic enzymes is that, in the presence of water soluble phospholipids, the substrate is united to the active place and the productive tertiary complex is formed in presence of Ca<sup>2+</sup>. The catalyzed reaction is produced and the hydrolysis products are freed. When the phospholipid is aggregated (micelles or vesicles), the enzyme is adsorbed to the phospholipid-water interface with its active place oriented towards the ordered arrangement of substrate molecules, it will bind a monomer molecule and, in the presence of Ca<sup>2+</sup> ions, an interfacial tertiary complex will be formed. Catalization is produced by the same reaction mechanism but with a drastic increase in the hydrolysis speed (between 10,000 to 100,000 times).

This increase in the hydrolysis speed resulting from the interaction of the enzyme with aggregated substrate is named "interfacial activation" and its mechanism has not been completely elucidated.

Crotoxine B is the crucial pharmacological agent of the crotoxine complex. It can reproduce all the effects of the complex but lacks specificity. The same occurs with regard to toxicity. (Please see hereinbelow).

B) Crotoxine A.

Its properties concerning the crotoxine complex.

Crotoxine A does not exhibit a detectable enzymatic or toxic activity, but it does exhibit two important properties in what concerns the action mechanism of the complex, i.e.: a) when Crotoxine A is added to a solution of basic phospholipase A<sub>2</sub> (Crotoxine B) a highly stable complex is spontaneously formed ( $K_d = 8.8 \times 10^{-11} M$ ) having a reduced isoelectric point (4 - 4.5) and molecular weight similar to that of the native complex, and B) in the Crotoxine A complex, the enzymatic activity of phospholipase A<sub>2</sub> is inhibited, but this occurs only when the substrate is in the aggregated state.

2.-Pharmacodynamics - Action Mechanism

The hydrolysis of phospholipids in the form of aggregates or biological membranes requires the binding of basic phospholipase A<sub>2</sub> to the phospholipid-water interface, and this binding is produced only after the dissociation of the complex. We have used crotoxine complex doubly marked (Crotoxine B with  $^{125}I$  and Crotoxine A with  $H^3$ ) demonstrating that crotoxine B only bonds to membranes, while crotoxine A remains in the overflow. We have found that the complex united in equal valence with dimethylsuberimide loses the capacity to bind with membranes, although it still maintains phospholipase activity.

We have proved that the catalytic place of Crotoxine B in the crotoxine complex is freely accessible to the monomeric substrate and maintains intact its functional capacity.

However, isolated phospholipase A<sub>2</sub> is capable of firmly interacting with phospholipid-water interphases, while the complex with crotoxine A seems incapable of interacting with said interphases.

The following conclusions can be arrived at from the above and other results:

(a) The formation of the complex between basic phospholipase A<sub>2</sub> and crotoxine A does not affect the structure and properties of the active place of crotoxine B, but prevents binding of the enzyme to phospholipid-water interphases and consequently inhibits enzymatic hydrolysis of substrates in the form of aggregates of biological membranes.

(b) The interaction of basic Phospholipase A<sub>2</sub> (crotoxine B) with aggregated substrate depends on the exposition of a specific area in the surface of the functional enzyme and topographically different from the active place. Only the free enzyme, with that exposed surface, will be able to bind to interphases and hydrolyze membrane phospholipids as well as exhibit the phenomenon known as "interphase activation".

(c) This specific region of the enzyme surface is the region covered by the formation of the complex with crotoxine A, which implies that the interaction between phospholipase A<sub>2</sub> with interphases and crotoxine A are mutually excluding, i.e., the formation of the complex with crotoxine A prevents interaction of the enzyme with membranes and the interaction of basic phospholipase A<sub>2</sub> with membranes prevents the formation of the complex with crotoxine A.

The observation of the citopathic effect of the crotoxine complex on Ehrlich ascitic tumor cells was fortuitous, but it was verified that concentrations in the range of  $10^{-11} M$  produced complete lysis of a culture in an interval of 60 minutes. Essays were made with pre-screening and screening culture lines (Dr. A. Meyer, Medicine Academy) and the same effect was observed. However, the most surprising discovery was the poor citopathic action in hepatocytes, fibroblasts and peritoneal culture cells.

In what concerns the action mechanism, the following observations are essential:

(a) Crotoxine B is the only component of the crotoxine complex capable of citopathic action on tumoral and also normal cells. In both cases, the addition of isolated crotoxine B produced evidence of cellular damage.

(b) Citopathic action is related to the enzymatic activity of crotoxine B. Selective blocking of the active place by treatment with p-bromophenacyl bromide (CANZIANI et al., 1982) determines the annulment of citotoxic activity. Discreet alterations were observed which appear to be related to the binding of the enzyme to the membrane, but these alterations apparently are not sufficient to cause lysis of the cells.

(c) The crotoxine complex (Crotoxine A - Crotoxine B) presents however a quite selective citotoxic action on tumoral cells.

(d) The applicant's investigations have proved that the Crotoxine A - Crotoxine B complex is capable of binding to membranes, so that the limiting step for the action of the crotoxine complex is the dissociation of sub-units A and B. The necessary condition for the crotoxine complex to exert its citotoxic action is the dissociation of the sub-units in the proximity of the target membrane. The most plausible explanation for this differentiated action of the crotoxine complex must reside in the existence of local physiochemical

conditions at the level of tumoral cell membranes promoting the dissociation of the complex. Said conditions prevailing in tumoral cells should not be sufficient to cause dissociation of the crotoxin complex in the proximity of normal cells.

(e) The changes in plasmatic membranes of tumoral cells has been known since 1958 and there is sufficient evidence to suggest that oncogenic agents alter numerous functions of plasmatic membranes consequently creating pleiomorphic changes observed in the membranes of said cells. In 1967, STOCKER described alterations in adhesiveness and the absence of contact inhibition, although these do not seem to be invariable properties in malign tumours (WALLACH, 1973). Similar phenomena occur in electrical uncoupling (WALLACH, 1973). The inhibition of contact growth, less prominent tumoral cells (STOCKER, 1967) and the greater fusogenic capacity (OKADA, 1969; POSTE, 1970) seem to run parallel with malignity. The changes in superficial potential of neoplastic cells has been observed in experiments with inner control (WALLACH, 1973), as well as changes in permeability (Sylvén et al, 1962) and immunological changes. The appearance of new antigenes, embryonary antigenes and deletion of certain selective antigenes in organs has been observed in numerous experimental and spontaneous tumours. It is difficult to establish which are the specific causes of selectivity. A possible cause may be the proton bomb (ATP-asa which actively transports  $\text{Na}^+$  into the cell and  $\text{H}^+$  out), induced by one of the growth factors. Selectivity is one of the most interesting points of our investigation. The dissociation of the crotoxin complex can be promoted by cooperative titration of the crotoxin A carboxylates. Although pH values of approximately 4 are necessary to produce dissociation, it must be borne in mind that these results are obtained in the balanced state. The prevalent condition in a cell is the stationary state, and therefore the dissociation degrees calculated in balanced states may be considerably modified, particularly when gradients occur in restricted volumes with diffusion barriers.

(f) The net result of dissociation of the crotoxin complex in the proximity of tumoral cell plasmatic membranes is that crotoxin B binds to the membrane, consequently producing hydrolysis of the membrane phospholipids. The hydrolysis products of phospholipase  $\text{A}_2$  and specially lysophosphatid (structure II) have detergent properties (in this regard, the denomination of lysoderivatives is due to lythic properties). Thermodynamic and geometric reasons prevent said products from being packed in stable laminar structures. In model systems (liposomes) the addition of lysoderivatives (1-3 mmol per 100 mmol of phospholipid) determines gross disturbances in permeability (for example), the outlet of saccharose and encapsulated cations, usually impervious) and greater concentrations of lysoderivatives determine the rupture of the laminar structure and the formation of micellar aggregates. Bearing in mind that biological membrane phospholipids contain long chain fatty acids (16 to 24 carbons), the hydrolysis products (Structures II and III) do not abandon the membrane and the increase of their relative concentration brings about alterations causing the outlet of mytochondrial and cythoplasmatic marking enzymes into the culture medium and morphological alterations (dilatation and rupture of mytochondria and endoplasmic reticula) leading to cellular lysis. At present, it is not clear whether said alterations result from internatization of the enzyme or the abrupt changes in the composition and ionic force arising from permeability alterations.

#### 40 Conclusions

The mechanism producing tumoral cell lysis can be explained as the result of enzymatic acitivity of crotoxin B. However, the point of greater interest resides in the target selecting mechanism of the crotoxin complex. It is considered that the crotoxin complex acts as a circulating deposit of inert crotoxin B, manifesting its activity only on cells having physiochemical conditions resulting from the dissociation of the crotoxin complex and thus being automatically vulnerable to attack by crotoxin B. Under these conditions, the tumoral cell would be a more efficient alternative target for capturing crotoxin B.

In addition, it is important to point out that phosphatidilinositol is among the phospholipids susceptible to being attacked by the enzyme. It is known at present that one of the critical signs inducing cellular proliferation is hydrolysis of triphosphoinositids by a membrane C-phospholipase. Hydrolysis products are inositol-tri-phosphate which can act as second messenger and a diglycerid responsible for the activation of a quinase protein (C proteinquinase) catalyzins phosphorylation of proteins. The hydrolysis product of phospholipase  $\text{A}_2$ , when acting on phosphatidilinositol is the corresponding lysoderivative, which is not an adequate substrate for endogenous phospholipase, and therefore could interfere the cellular proliferation mechanism.

In accordance with the conventional protocol of the National Cancer Institute (NCI - USA), murine tumours melanoma B16, colon tumor 26, Ridgway's ostogenous sarcome and Lewis carcinoma were used to evaluate antitumoral activity. In all cases, an increase in the average overlife time was required exceeding 20% and/or inhibition of local growth greater than 50% to demonstrate activity in comparison with non-treated controls. Said requirement is slightly lower than that usually required (average overlife exceeding 25%, growth inhibition exceeding 60%) due to the peculiar sensitivity of mice to the action of this toxine, as will be appreciated hereinafter.

The increase in the overlife average time was between 150% and 300% with 55-80% of survivors after 90 days with melanoma B16; about 200% with 60-80% survivors with colon tumor 26; 170-200 with osteosarcome and with Lewis' tumor.

The crotoxine complex was administered intramuscularly every four days. The result depended on the stage of the illness. The animals treated immediately after the implantation of the tumor responded much better than those treated when the illness was advanced.

Oral administration proved to be ineffective. After marking crotoxine B with  $I^{125}$  and forming the complex with crotoxine A, it was encapsulated in sphingomyeline liposomes. Under these conditions, measurable levels of crotoxine in plasma could be detected after oral administration, but the amount adsorbed varied considerably. Consequently, we have discarded at present oral administration.

## PHARMACOKINETICS

Pharmacokinetic studies were carried out using basic phospholipase  $A_2$  (crotoxine B) marked with  $I^{125}$  and in some cases the complex was doubly marked with  $H^3$  or  $C^{14}$  in crotoxine A by reaction with acetic anhydride.

### 6.1 Adsorption

Oral administration proved to be ineffective. After marking crotoxine B with  $I^{125}$  and forming the complex with crotoxine A, the complex was encapsulated in sphingomyeline liposomes. Under these conditions, measurable levels of crotoxine in plasma could be detected after oral administration, but the adsorbed quantity varied considerably. Consequently, oral administration has been discarded at present.

After intravenous injection to mice and rabbits, plasmatic concentration falls rapidly, arriving at 2% of the original amount within approximately 30 minutes. About 30% is recovered in urine.

After intramuscular administration, a peak of plasmatic concentration is observed about 30 minutes after the injection. Within the hour, plasmatic concentration is reduced to about 10% of the original amount and only traces thereof are detected in urine.

### 6.2 Distribution

The crotoxine A and B complex is soluble in organic or inorganic solvents.

Concerning concentration, basic phospholipase  $A_2$  is mainly concentrated in the liver (HABERMANN, 1972, FRAENKEL-CONRAT et al., 1976), wherein it is degraded, passing to the aminoacids pool. The introduced mark disappears almost completely between 6 and 8 hours after inoculation.

According to the result of HABERMANN et al (1972), basic phospholipase  $A_2$  or its complex with crotoxine A does not go through the hematoencephalic barrier as the amount of markation measurable in cerebrum or spinal medula of mice endovenously inoculated is negligible. HABERMANN and RAUDE have demonstrated that injection in cerebral ventricles produces convulsions.

The above data suggests that crotoxine is distributed extensively, although it has a brief average life and no persistent tissue concentrations appear.

Due to the swiftness with which the organisms catabolyses the complex, distribution studies were made administering high doses of marked crotoxine complex (Crotoxine B -  $I^{125}$ ) to albicans mice. Two groups of animals were sacrificed after 30 and 60 minutes after the intravenous administration of 220  $\mu$ g of crotoxine complex to determine the concentration or markations in different organs and tissue. Concentrations are expressed in Phentomoles ( $10^{12}$  mmol).

	TISSUE OR ORGAN	POST-INNOCULATION TIME	
		30 Min.	60 min.
5	Spleen	17500	2600
	Cerebrum and Spinal Medula	ND <sup>a</sup>	ND <sup>a</sup>
	Heart	3210	118
	Stomach	216	ND <sup>a</sup>
10	Lymphatic Ganglions	230 <sup>b</sup>	ND <sup>a</sup>
	Mesenteric Fat	280 <sup>b</sup>	ND <sup>a</sup>
	Liver	2208000	1560200
	Hypophysis	ND <sup>a</sup>	ND <sup>a</sup>
15	Small Intestine	366	ND <sup>a</sup>
	Large Intestine	154	ND <sup>a</sup>
	Bone Marrow	770 <sup>b</sup>	ND <sup>a</sup>
20	Skeletical muscle	178000	71000
	Urine	354000 <sup>c</sup>	2000 <sup>c</sup>
	Pancreas	1620	124
	Lungs	68000	780
25	Kidney	710000	266200
	Suprarrenal	86	ND <sup>a</sup>
	Thyroid	ND <sup>a</sup>	ND <sup>a</sup>
	Gallbladder	ND <sup>a</sup>	ND <sup>a</sup>
30	Total Recovered	3516432	1903052
	Percentage of Total	84.5%	45.4%
35	Note: The sacrificed animals exhibited serious respiratory insufficiency and were maintained with artificial respiration		
40	ND <sup>a</sup> : Non-detectable (< 70)		
	b <sub>DE</sub> : Average estimated data.		

c : Appearance in urine is due to high dosage employed. As the molecular weight of the complex is of 30000 same is filtered by the kidney.

### 6.3 Biotransformation

Biotransformation took place in the hepatic gland.

### 6.4. Excretion and final metabolites

The biotransformation products are aminoacids conducted to the metabolic pool to be employed by the organism. Disappear from plasma between 6 to 8 hours after administration. There are virtually no excretion metabolites.



### Studies carried out on tissue culture

The mechanism producing lysis in the tumoral cell can be explained as the result of enzymatic activity of crotoxine B; however, the point of greatest interest resides in the target selection mechanism (the malign cell) by the crotoxine complex.

It is considered that the crotoxine complex acts as a circulating deposit of inert crotoxine B and manifests activity only on cells having defined physio-chemical conditions, this resulting in the dissociation of the crotoxine complex and in the cell being exposed to the attack of crotoxine B. Under these conditions, a neoplastic cell would be a more efficient alternative "target" for capturing crotoxine B.

Essay: To demonstrate the cytolytic action of the crotoxine complex on cultured tumoral cells, the model (in this case Yoshida's sarcoma) was incubated with:

- 1) Crotoxine A during 60 minutes.
- 2) Crotoxine B during 60 minutes.
- 3) Crotoxine complex during 60 minutes.
- 4) A control group was observed.

Results: In the first case, after incubating 60 minutes Yoshida's sarcoma cells with crotoxine A, there was no antineoplastic effect, as was to be expected. In the second case (incubation with crotoxine B), lysis of malignant and normal cells could be observed within 20 minutes, demonstrating that this fraction is responsible for the antineoplastic effect without discriminating among cells. In the third case, after incubating 20 minutes the experimental sarcoma cells with the crotoxine complex, discriminative cellular lysis could be observed (only the malignant cell fractions) which reached a maximum at 60 minutes of incubation with  $6 \times 10^{-5}$  mg/ml of the crotoxine complex.

Similar essays were carried out on hamster fibroblasts with polyome virus, obtaining similar results.

### Studies carried out on experimental animals

In accordance with the conventional protocol of the National Cancer Institute (NCI - USA), the following tumours were used to evaluate antitumoral activity: Murine tumor melanoma B16, colon tumour 26, Ridgway's osteogenic sarcoma and Lewis' carcinoma. All cases required an increase in the average survival time exceeding 20% and/or inhibition of local growth exceeding 50% to demonstrate activity in comparison with non-treated controls.

Results : Melanoma B 16: Increase in average survival time between 150 and 300%, 55-80% survivors after 90 days.

Colon tumour 26: increase in average survival time of 200%, 60-80% of survivors.

Ridgway's osteogenic sarcoma and Lewis' carcinoma: Average survival time increase of 170-200%.

The crotoxine complex was intramuscularly administered every four days. Results depended on the stage of the illness. The animals treated immediately after tumour implantation reacted better than those treated when the illness was advanced.

### Clinical Essays

The following results were obtained four years after treatment of a group of 127 patients bearing advanced neoplasiae at different localizations. Eighty per cent of the group had received prior treatment of the conventional type.

#### N° 1 Breast Cancer

Twenty-five patients (pts.) were treated, 14 of which obtained complete remission (RC), 7 responded partially, 3 exhibited stabilization of the illness and 1 did not improve.

#### N° 2 Lung Cancer

Of 17 patients, 7 obtained RC, 7 partial remission (RP) and 3 did not improve.

N° 3 Pancreas Cancer

Of six patients treated, 3 responded in a complete manner and 3 in partial manner.

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N° 4 Melanoma

Of 9 patients treated, 6 achieved RC, 2 RP and one did not respond.

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N° 5 Unknown origin primitive carcinoma A

Sixteen patients were treated, 4 of which responded in a complete manner and 10 in partial manner. Two patients were considered non-responsive.

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N° 6 Uterus Cancer

Of 18 patients treated, 7 achieved RC, 8 RP and 3 were non-responsive.

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N° 7 Stomach Cancer

Six patients were treated, 3 achieved RC, 2 RP and one was non-responsive.

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N° 8 Colon Cancer

Twelve patients were treated, 3 achieved RC, 6 RP and 3 were non-responsive.

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N° 9 Prostrate Gland Cancer

Of 6 patients treated, 5 responded completely and 1 was non-responsive.

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N° 10 Sarcomas

Of 7 patients treated, 5 achieved complete response and 2 patients were non-responsive.

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Said formulations are used in therapeutical dosages, by intramuscular or sub-cutaneous injection or infiltrations.

The preparations can be realised following commercial techniques, such as liquid formulations for instance in aqueous vehicles having the usual additives (i.e., physiological solution), solution or emulsion eventually with other medicaments such as local analgesics, etc.

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The objects and advantages of the present invention are illustrated in the following example, although reactive products and amounts detailed therein as well as conditions and other operative details are provided by way of example only, it being understood that said example does not limit the scope of the invention.

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EXAMPLE

## 1. Obtainment of the crude complex

500 mg of lyophilised material are suspended in 5 ml of 0.2 M sodium chloride solution, bi-sodium ethylen diamine tetraacetate 1mM, and a buffer of ammonium formiate 20 mM pH 4.0. The solution is centrifuged at 10000 g for 20 minutes in a refrigerated Sorvall RC 2-B centrifuge at 4° C and the yellowish and slightly turbid supernatant is aspirated with a plastic syringe coupled to a Teflon tube constitute the starting material.

The remainder of the procedure is carried out in cold chamber at 2 - 4°C.

Step 1: The starting material is dispersed in a Sephadex G-75 column (Pharmacia Ltd. Uppsala, Sweden) measuring 85 x 2.5 cm (417 ml) adapted for ascending flow and pre-balanced with ammonium formiate buffer 0.1 M, pH 4.5 containing bi-sodium ethylen diamine tetraacetate 0.1 mM. The elution is carried out with the same buffer solution, recovering fractions of 3.0 - 3.2 ml at a flow velocity of 0.8 - 1.0 ml. cm<sup>2</sup>.hour<sup>-1</sup>. The crude complex is eluted in a value of K<sub>av</sub> ( $K_{av} = (V_e - V_o)/(V_o - V_i)$ ) of 0.44.

Fractions containing the crude complex are combined and concentrated by (a) lyophilization and (b) freezing, as upon defreezing the complex precipitates in an insoluble manner and it is possible to resuspend it by homogeneization in a Potter-Ehrlich homogeneizer having a Teflon pestle, or by ultrafiltration under nitrogen pressure in a chamber provided with a Diaflo UM-10 membrane (Amicon Co., Bloomington, Ma. USA) to a final volume of about 10 ml.

II. Separation of sub-units A and B from the crude complex

## Step 2:

The sample obtained in Step 1 is adjusted to a pH of 3.5 with acetic acid and is dispersed in a CM-Sephadex C-50 colum (Pharmacia Ltd., Uppsala, Sweden) having 8 x 2 cm and pre-balanced with a buffer solution of ammonium formiate 0.1 M, pH 3.5. Elution is commenced with a buffer solution of ammonium formiate 0.1 M, pH 3.5 (250 ml) to elute sub-unit A which, under these conditions, is not retained by the exchanger. The elutions is continued with a concave molarity gradient of the eluant (350 ml of ammonium formiate 1.0 M, pH 3.5) and finally with a linear molarity gradient (110 ml of ammonium formiate 1.0 M, pH 3.5 + 110 ml of ammonium formiate 3.0 M, pH 3.5), recovering 5 ml fractions at a flow velocity of 34 ml. cm<sup>2</sup>. hour<sup>-1</sup>. The elution diagram is followed, measuring adsorbency at 280 nm of eluted fractions. The last peak of protein eluted under said conditions corresponds to sub-unit B.

III. Purification of Sub-units

## Step 3: Purification of sub-unit A:

The fraction first eluted in Step 2 contains sub-unit A. The fractions are combined and dialyzed against 1000 ml (x 3 times) of a potassium phosphate (10 mM, pH 6.9) buffer solution. Alternatively, the combined fractions are concentrated by ultrafiltration under nitrogen pressure on a Diaflo UM-05 (Amicon Co., Bloomington, Ma. USA) and balanced with a potassium phosphate (10 mM, pH 6.9) buffer by chromatography on Sephadex G-25 (Pharmacia Ltd., Uppsala, Sweden).

The sample is applied on a DEAE-Sephadex A-50 column (10 x 1.5 cm) pre-balanced with potassium phosphate (10 mM, pH 6.9) buffer. Sub-unit A is eluted by means of a linear molarity gradient (100 ml of potassium phosphate 10 mM, pH 6.9 + 100 ml sodium phosphate 0.1 mM, pH 6.9).

Fractions containing purified sub-unit A are extensively dialyzed against 100 ml (x 3 times) of C1Na 0.15 M and concentrated by ultrafiltration as previously mentioned.

The recovery of sub-unit A is of 37.5 mg of protein. Obtained under the above conditions, sub-unit A exhibits only one precipitation arc by immuno-electrophoresis over agar gel.

## Step 4: Purification of Sub-unit B

Fractions containing sub-unit B (eluted in last place in Step 2) are combined and the sample is lyophilized or dialyzed against 1000 ml (x 2 times) of an ammonium formate buffer (0.1 M, pH 3.5) and chromatographed again on a CM-Sephadex C-50 column prebalanced with ammonium formate buffer (0.1 M, pH 3.5) as described in Step 2 with the exception that, once concluded the concave molarity gradient of ammonium formate up to 0.1 M, the elution is directly continued with ammonium formate buffer (0.2 M, pH 3.5) so as to concentrate the active fraction.

The fractions containing purified and concentrated sub-unit B are extensively dialyzed against 1000 ml (x 6 times) of ClNa 0.15 M.

The recovery of sub-unit B is of 75 mg of protein. Obtained under the above conditions and submitted to electrophoresis over polyacrylamide gel with sodium dodecylsulphate, it presents two strips with mobilities corresponding to molecular weights of 10000 (monomer) and 20000 (dimer).

Sterilization of purified sub-units:

The preparations of sub-units A and B purified in a ClNa solution (0.15 M) are sterilized by filtration through Millipore membranes in an ultraviolet chamber.

Recomposition of the complex starting from the purified sub-units:

Sub-units A and B spontaneously form a complex having a dissociation constant in the order of  $10^{-10}$  M and same is completed within the first minute after mixture.

Considering the results obtained in the use of the crotoxine complex for treating advanced cancer, the following conclusions are arrived at:

#### 1.-From the viewpoint of basic investigations

a) Concerning the citotoxic action, it has been demonstrated that same is related to the selective union of crotoxine to the tumoral cell membranes, respecting those of normal cells.

b) The final metabolites of the crotoxine complex integrate the aminoacids pool which, ultimately, would be employed by patients suffering malnutrition hypotrophy.

c) In the use of the crotoxine complex, no antigenic activity has been detected either in animals or human beings.

#### 2.-From the viewpoint of onocological therapeutics

a) Non-specific activity in any type of cancer or its metastasis.

b) No toxicity effects are produced, either acute, sub-acute or cronicly accumulative.

c) No psycho-organic dependency has been detected.

d) The complex has a capacity to penetrate and diffuse into any part of the organism where neoplastic cells are found. For example, the crotoxine complex traced with Tritum does not go through the hematoencephalic barrier, but if tumoral cells are located therein, it penetrates said barrier without inconveniences.

e) At therapeutic dosages, secondary or collateral effects are scarce and disappear after 2 or 3 hours from administration.

f) The complex does not interact with other medicaments, according to the above clinical experience with patients undergoing several treatments.

g) There are no counterindications. Experimental animals submitted to intravenous injection exhibited acute tubular nephropathy which, in some cases, caused death. According to the drug pharmacokinetics, as the sub-units of the crotoxine complex are low molecular weight proteins (P.M.), same deposit in the renal tubules causing irreversible toxic tubulopathy. These results would render intravenous inoculation to human beings impracticable.

h) To date, the following administration routes have been tried and found to be effective and safe: intramuscular, intratumoral, peri-tumoral, intracavitary, through fistular sections, intradermically, intrachirurgical and intramucose.

i) There is no accumulation in any organ, either before or after metabolization.

j) It exhibits a large analgesic effect.

k) No toxicity which could be attributed to tumoral lysis has been observed, such as hyperuricemia, hypercalcemia, etcetera.

- l) Therapeutic effect does not depend on a plasmatic level.
- m) Administration is daily and does not require a special technique or application procedure.
- n) Administration is carried out in ambulatory conditions.
- o) The drug is not united to plasmatic proteins for transport.
- p) No hemolytic charts or coagulopathy has been observed due to use of the drug.
- q) No electrocardiographic alterations or hemodynamic failures have been registered.

### 3.-Probable Hidden Metastasis Monitor

It is important to point out that patients frequently feel pain in the metastatic locations and/or in the primary tumor after administration of the drug. Eventually this fact could be employed in the diagnosis of hidden metastasis.

### 4.-From the Viewpoint of Economy in Public Health

Low production costs and the possibility of being administered in the domicile of the patients contribute to reduce expenses related to in-hospital attention to oncological patients.

### Claims

1. A composition of matter having pharmacological activity and having therapeutic benefits in the treatment of carcinomas, infectious and inflammatory diseases and endocrine disorders, comprising in an administrable form, effective amounts of crotoxin complex sub-units A and B in a suitable carrier.

2. A composition in accordance with Claim 1, in injectable form, which also comprises cobramine or melitine as analgesic component.

3. A composition in accordance with Claim 1 or 2, wherein in said complex structure and properties of active locus of B sub-unit are maintained and toxicity thereof is inhibited.

4. Procedure for obtaining crotoxin complex sub-units A and B, characterized in that it comprises separating by chromatography the crotoxin complex from crude venom of Crotalus Durissus Terrificus; concentrating the reunited fractions formed by eluting the absorbed crotoxin complex; dispersing in aqueous medium an insoluble product precipitated in said concentration stage; fractioning said sub-units A and B by chromatography of said dispersion in an adsorption column and eluting sub-units A and B with a buffer solution e.g. of ammonium formate having a pH of about 3.5; and purifying the separated eluted fractions containing said sub-units A and B, and eventually mixing said units to form the crotoxin complex.

5. Procedure in accordance with Claim 4, characterized in that the venom chromatography is carried out on a Sephadex C-75 column and the fractional chromatography of substances A and B is carried out on a CM-Sephadex C-50 column.

6. Procedure in accordance with Claim 4 or 5, characterized in that the eluant of sub-unit A is a solution of ammonium formate of approximately 0.1 M and having a pH of about 3.5, and that the separation of sub-unit B proceeds following the elution of sub-unit A with a solution of ammonium formate 0.1 M and pH of about 3.5 and ammonium formate of about 1 M and pH of about 3.5 in a volumetric ratio of 3.5/1 with a concave molarity gradient of said eluent and later with a solution of ammonium formate of about 1.0 and pH of about 3.5 and ammonium formate of about 3.0 M and pH of about 3.5 in a volumetric ratio of about 1:1 with linear molarity gradient, recovering the adsorbency elution fractions at 280 nm as a fraction containing the sub-unit B.

7. Procedure in accordance with Claim 4, characterized in that the purification of sub-unit A is carried out by dialyzing the eluted fraction containing said sub-unit which, once concentrated by dialysis, is concentrated by chromatography e.g. in a DEAE-Sephadex A-50 column, and subsequently eluted with a mild solution of ammonium phosphate and ammonium formate have a pH of about 6.9, the eluted fractions containing purified sub-unit A being concentrated by dialysis and subsequent ultrafiltration.

8. Procedure in accordance with Claim 4, characterized in that the purification of sub-unit B is carried out concentrating the eluted fractions by dialysis or lyophilization, chromatographing again on a CM-Sephadex C-50 column, eluting with concave gradient as stated in Claim 6, continuing the elution with a mild solution of ammonium formate of about 2.2M and pH of about 3.5, and dialyzing the combined fractions to form a fraction containing the purified sub-unit B.

9. The use of crotoxine complex sub-units A and B for the manufacture of a medicament for the treatment of carcinomas and vascular, infectious or endocrincus illnesses such as diabetes, and for treating pain in general.

10. A process for preparing the pharamceutical composition in acordance with claim 1, which comprises  
5 mixing therapeutically effective amounts of crotoxine complex sub-units A and B with a pharmacologically acceptable vehicle.

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Applicant: **Hernandez Plata, Guillermo Jose**  
**Santa Fe 3435, 4 "C"**  
**1425 Buenos Aires(AR)**

Applicant: **Costa, Luis Alberto**  
**Las Heras 3898 - 1 "C"**  
**1425 Buenos Aires(AR)**

Applicant: **Coni Molina, Carlos Maria**  
**Salta 1436 - 3 "A"**  
**1137 Buenos Aires(AR)**

Inventor: **Vidal, Juan Carlos**  
**5550 South Dorchester AP. 1106**  
**Chicago Illinois 60637(US)**  
Inventor: **Costa, Luis Alberto**  
**Las Heras 3898, 1 "C"**  
**AR-1425 Buenos Aires(AR)**

Inventor: **Hernandez Plata, Guillermo Jose**  
**Santa Fe 3435, 4 "C"**  
**1425 Buenos Aires(AR)**  
Inventor: **Coni Molina, Carlos Maria**  
**Salta 1436, 3 "A"**  
**1137 Buenos Aires(AR)**

Representative: **Pearce, Anthony Richmond et al**  
**MARKS & CLERK Alpha Tower Suffolk Street**  
**Queensway Birmingham B1 1TT(GB)**

Pharmaceutical composition based on crotoxine, process for preparing the active component and the pharmaceutical composition.

Crotoxine complex sub-units A and B obtainable by chromatographic isolation from the crude venom of Crotalus Durissus Terrificus, is useful for the treatment of carcinomes and vascular, infectious or endocrinous disorders, such as diabetes, and for treating pain in general.

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European Patent  
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# EUROPEAN SEARCH REPORT

Application number

EP 87 30 4427

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	DE-C- 675 605 (A. WOLFF) * Page 1, lines 1-16; page 2, lines 86-122; claims *	1-3, 9, 10	A 61 K 35/58
X	CHEMICAL ABSTRACTS, vol. 83, no. 11, September 15, 1975, page 19, ref.no. 90676r; Columbus, Ohio, US; A.T. TU et al.: "Cytotoxic effects of snake venoms on KB and Yoshida sarcoma cells" & RES. COMMUN. CHEM. PATHOL. PHARMACOL. 1974, 9(4), 783, 786 * Whole abstract *	1-3, 9, 10	
X	CHEMICAL ABSTRACTS, vol. 96, no. 16, April 19, 1982, page 46, ref. no. 135479r; Columbus, Ohio, US; F.S. MARKLAND et al.: "The application of a definbrinogenating snake venom enzyme in experimental tumor metastasis" & DEV. ONCOL. 1980, 4(Metastasis), 142-146 * Whole abstract *	1-3, 9, 10	TECHNICAL FIELDS SEARCHED (Int. Cl. 4) A 61 K 35/00 C 07 K 3/00
X	EP-A-0 063 091 (W. HAAST) * Pages 9-11 *	4-8	
A	* Claims 4, 11 *	1-3, 9, 10	
A	CHEMICAL ABSTRACTS, vol. 94, no. 11, March 16, 1981, ref.no. 77706h;		
X P E R I M E N T A L  P A T E N T  A P P L I C A T I O N  N O  .  / .			
Place of search Berlin		Date of completion of the search 05-07-1988	Examiner AVENDIKIAN
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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## CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

## X LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions,

namely:

1. Claims 2-8,10 and 1,9 partially: Concerning cancer
2. Claims 1,9 partially: For other therapeutic applications

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims,

namely claims: 2-8,10 and 1,9 partially



## Application number

EP 87 30 4427

- 2 -

# DOCUMENTS CONSIDERED TO BE RELEVANT

- 2 -

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	<p>Columbus, Ohio, US; H. FRAENKEL-CONRAT et al.: "Biological activities of crotoxin and amino acid sequence of crotoxin B" &amp; NAT. TOXINS; PROC. INT. SYMP. ANIM. PLANT MICROB. TOXINS, 6th, 1979, 561-567</p> <p>* Whole abstract *</p> <p style="text-align: center;">--</p>	1-10	
	<p>CHEMICAL ABSTRACTS, vol. 98, no. 18, May 2, 1983, ref.no. 155921y; Columbus, Ohio, US; H. FRAENKEL-CONRAT: "Snake venom neurotoxins related to phospholipase A2" &amp; J. TOXICOL., TOXIN REV. 1983, 1(2), 205-221</p> <p>* Whole abstract *</p> <p style="text-align: center;">-----</p>	1-10	<p>TECHNICAL FIELDS SEARCHED (Int. Cl. 4)</p>
XX			
Place of search		Date of completion of the search	Examiner
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p>			

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